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Leadership Content Knowledge

Mary Kay Stein
University of Pittsburgh

Barbara S. Nelson
Education Development Center

Drawing inspiration from Shulman's (1986) construct of pedagogical content knowledge, we propose that leadership content knowledge is a missing paradigm *in the analysis of school and district leadership. After defining leadership content knowledge as that knowledge of academic subjects that is used by administrators when they function as instructional leaders, we present three cases of instructional leadership—situated at different school and district levels—and examine each for evidence of leadership content knowledge in use. Based on a cross-case analysis, we argue that as administrative levels increase and functions become broader, leadership content knowledge becomes less fine-grained, though always anchored in knowledge of the subject, how it is learned (by adults as well as students), and how it is taught. We go on to suggest that all administrators have solid mastery of at least one subject (and the learning and teaching of it) and that they develop expertise in other subjects by "postholing," that is, conducting in-depth explorations of an important but bounded slice of the subject, how it is learned, and how it is taught. We conclude with an exploration of how content knowledge and leadership knowledge might be intertwined and suggestions for further research.*

Keywords: instructional leadership, leadership, subject matter knowledge

OVER a decade ago, Lee Shulman (1986) drew our attention to the importance of subject matter knowledge in teaching. Although the public holds the common-sense idea that teachers' knowledge of the subjects they teach is important, little effort in the field of research on teaching—at least to that point—had been devoted to exploring the level and kind of subject matter knowledge that teachers should possess. So neglected was teachers' subject matter knowledge that Shulman called it the "missing paradigm" in research on teaching.

Shulman's pronouncement led to a remarkable run of research on teacher subject matter knowledge and the creation of a new construct: *pedagogical content knowledge.* Teachers, he argued, need a different kind of subject matter knowledge than that possessed by mathematicians, scientists, or linguists. Rather than needing more (and more advanced) knowledge of subjects, teachers need a qualitatively different kind of knowledge—one that would enable them to help others to learn it. So, for example, elementary teachers do not need

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knowledge of advanced calculus or linear algebra; they need to understand how to make place value understandable to children who are learning subtraction with regrouping. The construct of pedagogical content knowledge was thus created to call attention to the fact that subject knowledge must be transformed for the purpose of teaching.

In this article, we contend that the study of administrators' understanding of subject matter and how it must be transformed for the purposes of leadership, has been similarly neglected in research on educational administration. Although the need for educational administrators to become instructional leaders has gained considerable currency (Rowan, 1995; Spillane & Halverson, 1998), most of the research in educational administration continues to focus on what effective leaders "do," not on how they think about what they do. Recently, a handful of researchers have begun to explore the cognitive underpinnings of effective leadership (Hallinger, Leithwood, & Murphy, 1993). Drawing upon early cognitive science research on problem solving and decision-making, most of this work focuses on how school leaders identify and frame problems in their schools. To our knowledge, such research has not examined the subject-matter-knowledge requirements of effective instructional leadership.

We argue here that administrators who profess to be instructional leaders—superintendents; deputy, assistant, or area superintendents; and principals,[1]—must have some degree of understanding of the various subject areas under their purview. Surely, principals and district leaders cannot know subject matter in the same way as do mathematicians or historians—nor even to the level that they expect their teachers to understand them. Nevertheless, as demands increase for them to improve teaching and learning in their schools, administrators must be able to know strong instruction when they see it, to encourage it when they don't, and to set the conditions for continuous academic learning among their professional staffs.

The kind of knowledge that will equip administrators to be strong instructional leaders we will call *leadership content knowledge*. Standing at the intersection of subject matter knowledge and the practices that define leadership, this form of knowledge would be the special province of principals, superintendents, and other administrators charged with the improvement of teaching and learning. As we will see later in this article, knowledge about subject matter content is related in complex ways to knowledge about how to lead. In some cases, subject matter knowledge appears to be transformed for the purposes of providing leadership for instructional reform. In other cases, administrators' knowledge of how to lead—how to build the culture of a school community, how to use professional development programs and other resources well, how to conduct a curriculum selection process so that it is perceived as legitimate and politically viable, how to plan for the systemic array of interventions that will be needed in order to successfully reform a system's academic program, and so on—appears to be transformed by newly learned subject matter. And, in still other cases, the two appear to be so tightly fused that they need to be actively disentangled.

Leadership content knowledge is a new construct. As such, the field of educational administration offers few, if any, images of what it might look like or the advantages it might confer to those who possess it. The purpose of this article is to begin the process of fleshing out the construct of leadership content knowledge, providing an initial foray into how and why subject matter knowledge matters in educational leadership. First we lay out the ideas about leadership and learning that undergird this article. We then analyze three cases of instructional leadership—an elementary principal doing classroom observations, an associate superintendent chairing a curriculum selection committee, and a central office team designing district-wide mathematics education reform—and examine each for evidence of leadership content knowledge in use. Through the succession of cases we build up a complex view of what leadership content knowledge is and how it is used. Finally, we do a cross-case analysis, pulling out those general characteristics of leadership content knowledge that appear in the cases and raising questions for future research.

The cases we examine in this article come from two different research projects. The first two come from a study directed by the second author, in which a group of administrators who had taken a course in mathematics education (Grant, et. al, 2003 a, b, c) was studied as they explored how the ideas in that course connected to their ongoing administrative work.[2] These administrators were interviewed a number of times during the course of the research, and were observed as they went about their work at school.

The third case comes from a study of Community School District #2 in New York City directed by the first author. In its early phases, the study focused on how district leaders and school principals thought about and led district-wide reform in elementary literacy. As the district added mathematics to its agenda, the study shifted to include interviews and observations with principals, district leaders, and teachers surrounding ways in which they saw the mathematics work as both similar and different from the literacy work.

Examining Leadership and Learning

There are a variety of ways to think about where leadership resides in educational organizations (e.g., distributed vs. positional theories[3]) and how leaders might go about encouraging and shepherding the instructional improvement process (e.g., accountability vs. learning models[4]). In this article, we primarily deal with leaders in positional authority; we do, however, describe ways in which positional administrators interface with subject-matter specialists to support teacher improvement and sketch out how administrators can build on the knowledge of others in their organizations. In doing so, we point to some of the limitations of models of educational leadership that invest all leadership functions in individuals with line authority and begin to identify ways in which expertise and authority are distributed throughout an organization.

The view of leadership for instructional improvement that underlies this article includes elements from both learning and accountability views of leadership. One of the greatest strengths of positional administrators acting as instructional leaders is the accountability they bring to the reform process by virtue of their positions as evaluators. Professional development for teachers is not sufficient to change instructional practice, especially across an entire system. Teachers must believe that serious engagement in their own learning is part and parcel of what it means to be a professional and they must expect to be held accountable for continuously improving instructional practice. Similarly, principals must not only be capable of providing professional development for their teachers, but also have the knowledge, skills, and strength of character to hold teachers accountable for integrating what they have learned in professional development into their ongoing practice. District leaders, in turn, must be able to support principals' learning and be knowledgeable enough to be able to hold principals accountable in a fair way. Given their roles as both supporters and evaluators, administrators constitute a critical leverage point in the systemic improvement of instruction.

The diagram shown in Figure 1[5] depicts the relationships between educators at different levels of the educational system and provides a framework for identifying and analyzing the knowledge they use in doing their work.

In this diagram, the personnel in the left–hand box at each level perform both leadership and teaching functions for the personnel in the right-hand box at the same level. At the heart of the diagram is the subject matter of instruction—the smallest oval. One layer out, in the second oval, we find the actors related to subject matter in the classroom—teachers and students. These two inner-most ovals form the "technical core" of education (Meyer & Rowan, 1977), teaching and learning in the classroom. In the next layer we find principals and teachers. In this layer, administrators are viewed as teachers (and leaders) of teachers, and teachers are viewed as the learners. The fourth layer out shows district leaders (superintendents and their deputies or assistant superintendents) as the teachers (and leaders) and other adult professionals (principals, teachers, other central office staff) as the learners.

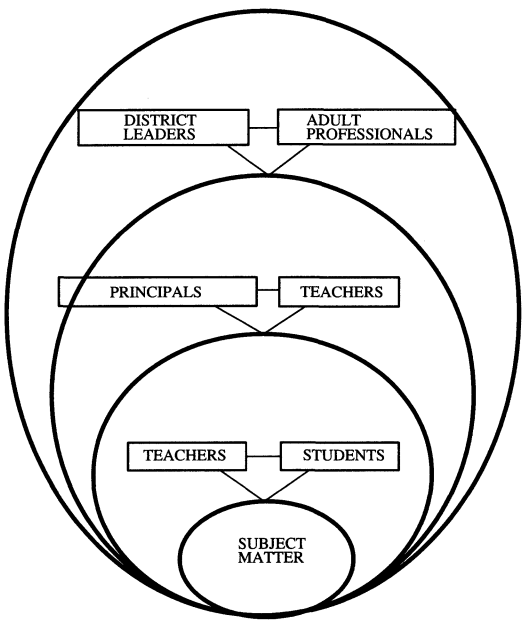

FIGURE 1. *Nested learning communities.*

Knowledge of the Substance: What the Work is About

Referring to Figure 1, the substance of what is taught, learned, and managed consists of all content and practices "beneath" the "teachers" and "learners" at each level. In the classroom, teachers interact with learners about subject matter. The teachers' task is to socialize students into the world of literate knowers within each of the subject matter discourse communities. To do this, however, teachers need to know more than subject matter. They also must know something about how students learn a subject matter (typical challenges and stumbling blocks, ways of connecting new ideas to previous ideas, and so on) as well as information about the best ways of teaching that subject matter (e.g., particular representations that are recognized as powerful for fractions, ways of pulling together disparate students' conceptions of proportionality, etc.). This is the knowledge that has been referred to by Shulman as pedagogical content knowledge.

The substance of work in the third layer is more complex. If an important task for principals is to assist teachers to improve their performance in the classroom, the substance of their work together will include everything in the inner two ovals: subject matter, what is known about how to teach the subject matter, and how students learn the subject matter. The knowledge required to do this, however, involves more than knowing the contents of these two inner ovals. It also includes knowing something about teachers-as-learners and about effective ways of teaching teachers.

In the fourth layer, district-wide issues are being dealt with and the "learners" may be a variety of adults in the school district depending on the task—principals, teachers, subject matter specialists, etc. If the learners in this outer oval are principals, the substance of the work expands, as does the knowledge needed to carry it out. Administrators who train principals must know everything in the inner three ovals *plus* what principals need to know. Such knowledge goes above and beyond what professional developers need to know and includes issues such as how to lead an organization in which whole groups of teachers improve. District leaders must also have knowledge of *how principals learn* (i.e., characteristics of principals as learners—what pre-conceptions do principals often bring to the learning enterprise? How can those be overcome? How much do principals typically know about facilitating teacher learning?)

Knowledge of How to Facilitate the Learning: The How of the Work

Not so obvious in the diagram that appears in Figure 1 is that at each level educators are engaged in working and learning together in *communities*—i.e. principals work with *groups* of teachers as well as individuals and district administrators work with *groups* of principals and others, as well as individuals. We take a socially interactive, constructivist orientation toward teaching and learning—at all levels of the system. Constructivist views assume that learning involves active creation on the part of the learner; new ideas and competencies are not passively absorbed but rather become meaningful and useable only by active integration with pre-existing knowledge and understandings.

We also believe that the learning of complex knowledge and skills is supported by interaction between individuals in settings in which individuals work toward the accomplishment of common goals and in which varying levels of expertise exist (Lave & Wenger, 1991; Wenger, 1998; Wertsch, 1985; Rogoff, 1994; Vygotsky, 1978). In our view, learning is spurred by asymmetries in expertise, that is, in situations in which one individual knows more or different things than the other. Although who is most expert can shift depending on the task at hand, the "teacher's" or "leader's" job is to have a grasp on where expertise resides in relation to particular tasks and to then arrange environments that make interactive learning possible.

Hence, the role of administrators-as-teachers (like the role of teachers in the classroom) is not one of transmitting knowledge, but of assuming responsibility for (a) understanding the learning needs of individuals; (b) arranging the interactive social environments that embody the right mix of expertise and appropriate tasks to spur learning; (c) putting the right mix of incentives and sanctions into the environment to motivate individuals to learn; and (d) ensuring that there are adequate resources available to support the learning. We view knowledge of how to create these kinds of environments for learning as an important competency specifically related to how to *lead* the improvement of teaching and learning in an organization.

The Cases

All of our cases explore the knowledge that administrators need to effectively orchestrate activities that facilitate improvement in teaching and learning in the classroom One of the cases is situated in the third, or school-level, oval of Figure 1; the other two are situated in the fourth, or district-level, oval.

The first two cases look at two administrators who worked to improve their understanding in one particular subject area—mathematics—and then applied that new understanding to their leadership practice. In the first case, we observe a principal conducting classroom observations of mathematics instruction and the associated pre- and post-observation conferences with teachers. Using Figure 1 as our guide, we identify what knowledge of mathematics she used (the inner most oval), what knowledge of students-as-learners of–mathematics and teachers-as-teachers-of-mathematics she used (the second oval) and, finally, what knowledge of teachers-as-learners she used (the third oval). In the second case, we observe the process by which an associate superintendent led teachers and parents in the district-level selection of an elementary mathematics curriculum. Again using Figure 1, we identify what knowledge of mathematics he used (first oval), what knowledge of students-as-learners-of-mathematics and teachers-as-teachers-of-mathematics he used (second oval), what knowledge of teachers-as-learners he used (third oval), and the knowledge of other adults-as-learners (school committee members, parents on the selection committee, etc.) he used. In both cases, we identify the specific kinds of knowledge that the administrators used in performing their administrative duties. We also examine their knowledge of how to guide the learning of groups of teachers and others in the school and district community. Looking across the cases, we can begin to discern how these kinds of administrator knowledge influenced the enactment of two traditional administrative functions.

Not only do leaders undertake their work informed by new knowledge of mathematics, as in Cases 1 and 2, but also informed by their pre-existing knowledge and commitments in other subject areas. Our third case illuminates this dynamic as we examine how central office educational administrators in a mid-sized urban district (approximately 43,000 students) undertook system-wide mathematics reform on the heels of a successful district-wide literacy reform. After presenting the account of New York City's Community School District #2's transition from a "literacy-only" reform to a broader reform strategy that also included mathematics, we examine how leaders' content knowledge in literacy informed their understandings of how to organize instructional improvement in mathematics. By analyzing similarities and differences in the content knowledge associated with reform in these two content areas, we gain new leverage on what kind of content knowledge matters for leadership.

Referring to Figure 1, the third case takes up issues that lie in the fourth oval, that is, how the knowledge of top administrators influences their work with principals as learners and the entire district as a learning community. Using Figure 1 as our guide, we identify the knowledge of mathematics that they used (the inner most oval), the knowledge of students-as-learners and teachers-as-teachers that they used (the second oval), the knowledge of teachers-as-learners that they used (the third oval), and, finally, the knowledge of principals-as-learners that they used (the fourth oval).

Case #1: Claudia West[6]: Using Classroom Observation and Teacher Supervision to Identify Professional Development Needs

A ubiquitous function of the principalship is classroom observation and teacher supervision. Unfortunately, principal observations traditionally occur infrequently and mostly to fulfill administrative needs such as recommendations for tenure. Teachers often perceive these observations as less-than-helpful, claiming that principals focus solely on non-substantive aspects of their practice such as the neatness of bulletin boards, classroom management routines, and the extent to which students are well behaved. Without substantive focus and/or continuity over time, teacher observation and supervision often becomes a symbolic routine rather than a meaningful intervention. In the case of Claudia West, we observe how an administrator's knowledge of mathematics and how children learn it influenced her observational routines such that they became something very different from this.

Claudia West is the principal of a K–5 school in the small city of Hillsville in central Massachusetts. While she has been an elementary school principal for 14 years, the year we observed her was Mrs. West's first year as principal at this

school and in this district. Mrs. West chose to use her work with us as an opportunity to explore the degree to which teachers adapted their mathematics instruction to meet the needs of all children in their classes—those who were performing below, at, and above grade level.[7] However, shortly into the project, her work with teachers took an unanticipated turn: the exploration of how the teachers in the Clinton School understood the nature of mathematics learning and teaching, itself. This took the form of an extended inquiry on Mrs. West's part of how they understood the nature and role of mathematical exploration in the process of mathematics learning.

Mrs. West's observation practice included the distribution of a questionnaire to each teacher before the pre-observation conference, the purpose of which was to signal to teachers the areas she wanted them to be thinking about. After observing the first lesson in the series, Mrs. West commented that she felt that the lesson had been too intellectually controlled—the intellectual structure of the work had been prescribed by the teacher and there were no intellectual choices for the children to make.[8] She then realized that there was no question on her questionnaire addressing the issue of mathematical exploration, indicating to teachers that she thought it important and that they should reflect about it. She said,

> I want a question that talks to the exploratory . . . How were the children empowered? Somehow, it wasn't just that they could get their own slate and go to their own spot. But how were they intellectually empowered?

Mrs. West decided to add the following question:

> What opportunities for math exploration will you provide during this lesson?

She used this question in the next two observations, but was dissatisfied when she discovered that the teachers didn't seem to understand the question, so she modified it for the final observation in the series. The final form of the question read:

> What opportunities are provided for students to explore ("play with," "mess around with") mathematical thinking/ideas/concepts during this lesson?

This modification was an attempt to communicate to the teachers what she meant by "mathematical exploration."

Mrs. West's struggles with this question took place over several months. They reveal both what she was discovering about the teachers' thoughts about mathematical exploration and what she herself meant by the term.

When she first asked the question about mathematical exploration, one teacher's answer, "Children will be working with manipulatives. They will be working in pairs," suggested that the teacher interpreted the term "math exploration" to mean "using manipulatives." When Mrs. West pressed further, asking the teacher what the children would actually be doing and, in successive questions, searched for the places in the lesson where the children would have latitude and flexibility, she discovered that in a lesson about the relationship between ones and tens, the children would have flexibility in the way they recorded the numbers on their worksheet. When asked if the children "had actually explored the mathematical idea [of the relationship between ones and tens] with the . . . little tiles" in previous lessons, the teacher could not remember and said she "didn't have an answer for that." Mrs. West later concluded that this teacher had not understood what she meant by the term "mathematical exploration."

> It didn't sound like [the teacher] really understood the depth of that question [about mathematical exploration]. [It] was more like [she thought] you're moving things around so you're exploring. But what is the mathematical thinking that goes behind what it is that you're doing? That was the next layer that I wasn't sure she understood.

Mrs. West, herself, was clear that there was a relationship between a manipulative and the idea it represented:

> Messing around, both with the manipulatives and with the ideas, go together. They're not the same thing, but they're related. There's a partnership there.

She saw the "messing around" with manipulatives as a context for children to test their hypotheses about mathematical ideas. She describes this while talking about a manipulative that one of the teachers had made to illustrate the relationship between certain equivalent fractions—a manipulative that the teacher called a "fraction fringe." A fraction fringe was constructed of a stack of overlapping rectangular pieces of paper stapled

together at one end. Each piece of paper was partially split so that, at the bottom level there was one piece of paper, at the next level a piece of paper split into two halves, at the next level a piece of paper split into four quarters, and at the top level a piece of paper split into eight eighths. Students could use this to see, for example, how many fourths would be equivalent to one (the whole). Mrs. West used the example of the fraction fringe to describe how she saw the relationship between "messing around" with the manipulatives and the ideas simultaneously. She said,

> Let's take the case of the Fraction Fringe. Let's say [the students wanted to compare] a half and . . . two quarters. They could put them next to each other. They could lay them on top of each other, . . . [The children] are testing what their hypothesis is. Half is the same as two quarters. . . . They can test it. They can take the two quarters and they can put them on top of . . . [the half] and they prove it to themselves. It's like they test the hypothesis.

For Mrs. West, mathematical exploration was the process of "messing around" with a manipulative, in order to test a hypothesis about a mathematical idea. She wanted mathematics classrooms at the Clinton School to provide students with sufficient intellectual flexibility and latitude for such explorations. In fact, mathematical exploration was quite central to Mrs. West's view of mathematics teaching and learning. For her, it was the process by which children individually built meaning for mathematical ideas.

In our initial interview with Mrs. West, she had explained how she viewed children's learning as the individual process of filling in gaps in an ever-evolving lattice—a process through which personal meaning was built. She said:

> I used to think . . . that you started with certain bits of information and, like layers on a layer cake, you just kept on adding new layers. And that if you mastered layer one and then you added layer two. . . . Along the way . . . this huge cube would emerge that was [the person's] knowledge. And it seemed that [with] some people you could build the cake faster than others because they were acquiring the knowledge at a more rapid pace.
>
> But now I think it is more like a lattice-work with a whole bunch of gaps. And people construct knowledge based on a lot of things. Not just what their parents tell them or what the teacher tells them, but their experiences in the world. And so they're building a framework all the time. Trying to make connections. . . . But I think that children when they learn, they're just sort of . . . filling in the spaces [in the lattice] with information. . . . adding to what it is that makes meaning for [them].

This is quite a striking and sophisticated image—that children structure their knowledge and that such knowledge structures are not hierarchical but network-like. It's not that learning one piece of information depends on prerequisite pieces of information being in place, but rather that pieces of information are connected to each other in many different ways. Children are continually building their own knowledge from a wide range of personal experiences—connecting pieces of knowledge to one another and filling in gaps. For Mrs. West, learning involves moments of insight, which she refers to as "ah-ha's," which happen when gaps in the lattice get filled and one idea becomes connected to others. She took mathematical exploration to be the process by which children tacitly test an hypothesis about how a mathematical idea fits into their own, personal, lattice or knowledge structure. By the time of the final observation in the series we observed, Mrs. West was quite concerned by her discovery that many teachers in the Clinton School apparently did not understand the concept of mathematical exploration as involving the exploration of mathematical ideas (though some did). She went on to talk about how she planned to talk with the school's curriculum specialist to see if she could do some informal work with the teachers on the nature of mathematical exploration and its role in children's learning. In her view, the teachers would need to experience learning mathematics in a new way, including the exploration of mathematical ideas, in order to understand. She had been to a teacher workshop several years before that was the kind of professional development she wanted for the teachers at the Clinton School. At that workshop, teachers were treated as learners of the mathematics of the elementary curriculum. Mrs. West described one session:

> In the particular group I was in, there were two standard algorithms that everybody had . . . learned. . . . but there were really two different ways. . . . and there were so many ah-ha's. We were forced to do it another way. Figure it out another way. And people were having so much fun, . . . when they saw someone else's idea. It

> was like, 'Wow, I never would have thought of that.' There were just so many ah-ha's and sparks of enthusiasm and to me that's how teachers really can change, is that when they experience it, something at their level, but through the eyes of the learner instead of through the eyes of the teacher.

Mrs. West had hold of a very important idea—that teachers may never have had the experience of exploring mathematical ideas and needed to experience it for themselves, as learners, in order to understand how it could function in their students' learning.

Analysis

Mrs. West used the process of classroom observation and supervision not only to evaluate particular teachers but also to diagnose the adequacy of mathematics instruction, school-wide, and develop a remedy, if needed. She discovered that, though they were using a curriculum that was designed to provide opportunities for students to explore mathematical ideas, few teachers were actually providing such opportunities. Indeed, few even understood what the term "mathematical exploration" might mean. Mrs. West identified this need and had a very specific view of the kind of professional development that was needed.

What did she need to know in order to do this? What was her leadership content knowledge? As we analyze what Mrs. West knew, we can see several of the dimensions of knowledge—knowledge of mathematics itself, knowledge of how children's mathematics knowledge develops, and knowledge about teacher learning—that are depicted in Figure 1. (While this episode does not allow us to specify all that Mrs. West might have known about these, it does provide evidence that these dimensions were part of the content knowledge that she used in exercising instructional leadership in her school.)

Knowledge of mathematics (the inner-most oval)

Mrs. West was quite comfortable with the mathematics of the elementary school curriculum. She could look at a lesson, see what mathematical ideas the lesson provided the opportunity for children to work with, and assess whether or not there were missed opportunities for children to explore those ideas. She also could construct modifications of such lessons, on the spot, when talking afterwards with the teacher. When observing mathematics classes she frequently discussed with the children the specifics of the mathematics they were working on.

Knowledge of how children learn mathematics and how teachers can assist their learning (the second oval)

Mrs. West understood that children are continually constructing their own mathematics knowledge, building individual and unique knowledge structures, and that they use manipulatives (and other problem-solving techniques) to test hypotheses about mathematical ideas and add new mathematical information to their evolving network of ideas. She wanted mathematics classes to provide students with the maximum possible opportunity to explore mathematical ideas and add them to their knowledge structures. She was interested in how various instructional strategies supported children in doing this and enjoyed talking with teachers about how their strategies had worked in the class she observed. She was quite interested in the ways in which particular manipulatives represented mathematical ideas, and which manipulatives were likely to help students understand those ideas, depending on the child's learning style.

Knowledge of how teachers learn to teach mathematics and how others can assist their learning (the third oval)

Mrs. West also knew that teachers are continually constructing their own knowledge about mathematics, learning, and teaching, and that they do this in part through reflection. Her questionnaire was designed to put important ideas out for teachers to reflect on. When she did not observe mathematical exploration in the first classes she observed, she put a question about it on the questionnaire, with the intent to give teachers the opportunity to reflect about it. But she discovered that the term "mathematical exploration" was so far from the teachers' frame of reference that many couldn't connect with it. In that circumstance, Mrs. West's ideas about teacher learning led her to decide that something more than the opportunity for reflection that she could provide was needed. In her view, what the teachers needed was the opportunity to think about and explore mathematical ideas for themselves—to approach the ideas of the elementary mathematics curriculum from the point of view of the learner, rather than from the point of view of the teacher, so that they

could experience what it felt like to suddenly understand how an idea fit into their own knowledge structures.

Knowledge of how to guide the learning of teachers within a community

As we explore the nature of leadership content knowledge, the case of Mrs. West suggests that such knowledge has several dimensions, including knowledge of mathematics, knowledge of how children's mathematical knowledge develops, and knowledge of how teachers learn. It does not, however, provide us with much insight into how she would arrange professional learning opportunities for her teachers as a group. Her conceptions of what teachers needed to learn appeared to be primarily held at an individual teacher level. Our next case, that of Dr. James Garfield, extends our understanding into this realm.

Case #2: James Garfield[9]: Reform in Curriculum Selection[10]

Another ubiquitous function of educational administration is curriculum selection. Traditionally, curriculum selection committees have met for a relatively short time to look through the newest editions of familiar curricula. During the curriculum selection process attention has often been focused on practical aspects of the curriculum's usability, such as ease of navigation for the teacher, appealing graphics, etc, and political aspects of its acceptability, such as the degree to which it would be expensive to implement or be sufficiently different from earlier curricula that parents and perhaps teachers would not understand it or approve of it (Goldsmith, Mark & Kantrov, 1998). In the case of James Garfield, we observe how an administrator's knowledge of mathematics and mathematics learning influenced his leadership in this area such that the process became something very different from this.

Dr. Garfield had been associate superintendent of schools in Avon, a small school district, for eight years when he participated in our mathematics seminars for administrators. Shortly after Dr. Garfield completed the seminar it was time for his district to select a new curriculum in elementary mathematics. Based on his experience in the mathematics seminar, Dr. Garfield rejected as no longer appropriate his district's standard procedure for curriculum selection, which consisted of evaluating candidate curricula against a check-list of criteria such as coverage of a list of mathematical topics or ease of use; rating each curriculum against each criterion on a scale of *1 to 5;* and calculating the numerical result. He was willing to sacrifice the efficiency and apparent objectivity of such a procedure in exchange for a process that would assess candidate curricula on the dimensions that mattered for learning and teaching, as he now saw them. The issue now was how a candidate curriculum supported students in their efforts to build mathematical ideas in their minds. As he put it,

> I think the short hand of it would be to move the school system in a way in which we would be known as a school system whose children were mathematical thinkers as opposed to arithmetic practitioners, or something of that sort . . . And the vision was really teachers thinking with [students] about mathematics.

The practical challenges of curriculum selection were still salient for Dr. Garfield. But in the curriculum selection process this time, Dr. Garfield wanted to strike a different balance between consideration of practical issues and consideration of educational ones. He wanted to reinvent his district's curriculum selection process, using the process of curriculum selection as an opportunity to create a community of teachers and parents who examined the ideas about mathematics, teaching, and learning that were embedded in the several Standards and Frameworks documents by debating about what it meant for a student to be a mathematical thinker and the way in which the curricula under examination supported that goal.

As one of the first tasks in this project, Dr. Garfield worked with EDC staff to design a several-months-long curriculum selection process that began with an opportunity for all members of the selection committee (elementary, middle, and high school teachers, and some parents) to get oriented toward the philosophy behind standards-based mathematics education and to establish some shared understanding of the meaning of terms commonly used in standards-based mathematics instruction (e.g., hands-on learning, mathematical inquiry). He understood that people on the committee might use the same words but mean very different things by them, and he wanted committee members to have the opportunity to be explicit about the kind of mathematics education they were seeking for students. At its first meeting,

the selection committee viewed and discussed a short videotape of a standards-based classroom and discussed excerpts from the NCTM Curriculum and Evaluation Standards and the Massachusetts Mathematics Framework. Dr. Garfield then described the overall process that they would use: examining one curriculum each week for six weeks and using a set of open-ended questions that focused attention on the mathematics content of the curriculum and the ways in which each curriculum supported the development of students' mathematical thinking. About this process, he later said,

> The exercise of forming those questions . . . gave me the courage, . . . the willingness . . . in each session to say to the teachers not so much, "What does this exercise do?" Or, "What does this unit do?" but "What kinds of thinkers will this create?"

Centering the discussion on what kind of mathematical thinkers students would be if they were taught from each candidate curriculum allowed Dr. Garfield to stay focused on the central intellectual issues that needed to be addressed and not get deflected by peripheral issues. As he put it, reflecting back on the process:

> For me the initial experience [of forming the questions] was truly instructive in terms of coming to what I thought of as the essence of the core . . . issues here. And letting the rest take care of itself . . . I never felt that I got distracted by the teachers' interest in the management stuff. I knew at various points that politically I had to worry about that, but . . . that's not how I got channeled . . . because I had a stronger, more powerful idea of mathematics education being central to kids' thinking . . . 'How would the child's math education be different as a result of this program?' That [question] seemed to provoke some pretty interesting responses from [the selection committee].

Avon's new curriculum selection process took place over an extended period of time and was driven by the guiding questions. Each week, from January until June, teachers and parents on the curriculum selection committee systematically analyzed the kind of mathematical thinkers that students would be if the district adopted the candidate curriculum. This provided committee members with the opportunity to think about the nature of learning and teaching, as well as selecting a text.

In January, the administrator framed the process for the committee:

> The heart of your discussion is to say at the end of K–6 with this series, 'What would a child think math is, geometry is, be ready to do in probability and statistics? As a mathematics learning experience, what does this do for a child's intellectual development?' That's the question you need to be addressing . . . You're not supposed to talk about the [physical] quality of the materials now. I'm asking you to say, "What would a child think about the base ten system as a result of this experience?" . . . That's the level of discussion I want you to be having.

Old habits of behavior were not easy to shake off. In the early meetings Dr. Garfield tended to stand in front of the group, ask a question, listen to a teacher's answer, then ask another teacher a question. The discussion tended to go back and forth between administrator/chair and individual teachers. When asked, Dr. Garfield said that this was his old style of teaching:

> It definitely was an old way of teaching. Yes. And the way I would explain it is this: that the old way of teaching was the students as totally unrelated individuals relating to me. As opposed to my being there in order to let the students relate to each other. To create a way for them to relate to each other.

He went on to explain that he had always wanted his students (and, in this case, the teachers and parents on the committee) to feel safe and affirmed. He then worked with the EDC staff to create a process and context in which the members of the committee could talk directly to each other, and through which their ideas could be listened to and built upon by others with profoundly affirming effects. As he later described it,

> I hadn't actually thought of the teachers wanting to relate to each other . . . Or their wanting to build on each other's ideas. My orientation is to reward people for their ideas, to congratulate them, thank them, and be warm. As opposed to the school of thought that says, it's about ideas, and we can still be affirming and supportive, but let's put the ideas on the table. I wasn't working on the idea level at all. I was working on . . . keeping people safe, keeping myself safe . . . What you showed me was that people feel really affirmed and validated and rewarded when their idea goes someplace . . . It's really a huge sense of accomplishment if your idea has led to another

> idea. That we're not just protecting each other as people, but we're . . . strong enough, brave enough, mature enough to make ideas happen around the table. And that was a new idea for me in this sort of environment. Yes it was.

As the weeks proceeded, the committee settled into using the guiding questions and the vision of children as mathematical thinkers to structure their assessment of candidate curricula. Dr. Garfield's role and behavior shifted—away from advisor, coach, lecturer, and toward a more facilitative stance—and he finished the project in the firm belief that his goal of changing the focus of the selection process had been accomplished. As he put it,

> Questions . . . were raised every week about kids' learning and thinking and how the [instructional] process would be different and how the school system would be different . . . I think [committee members] began to think that they were doing something that was like rock bottom, as opposed to tinkering.

In the end, the committee chose *Investigations in Number, Data, and Space,* a much more progressive curriculum than Dr. Garfield had earlier predicted they would select—a curriculum that focused on the development of children's mathematical thinking as well as the acquisition of mathematical facts and procedures.

Dr. Garfield took a deep breath, as he anticipated the political and administrative processes ahead for him in effecting the formal approval of this curriculum. He explained that presentations to the School Committee are quite carefully crafted. In order to keep the agenda moving smoothly along and to maintain the School Committee's confidence in the professional staff, the work being presented to the School Committee was typically portrayed as straightforward and unproblematic. In making presentations before the School Committee one wants to use scarce time efficiently, design the presentation so that it anticipates questions that School Committee members might have and, since School Committee meetings are broadcast on the community access channels of local cable television, not embarrass anyone. As Dr. Garfield noted, presenting the committee's choice of the *Investigations* curriculum would be a matter of staying in "the chute;" i.e. staying in a narrow shipping lane.

> You have to sail in a very narrow shipping lane to get ideas through School Committee and to get out of it so that the next item gets off and there's no unfinished business . . . If you do too much or too little you go aground the way that ship did. [But] if you kind of keep your focus, you go [he makes a swooshing sound] right through. . . . I think it's a chute. If you don't get into the chute with the right information, it becomes a long presentation and then the chairman and the school superintendent are looking at watches and the people who are behind you on the agenda are furious. . . . So you have to do something structured, clean, clear.

This presentation, coupled with the subsequent tasks of providing the materials and teacher professional development that the implementation of *Investigations* would require, seemed challenging to him, but he felt he could offer the students in his district no less, even if it would require a great deal of work on his part over the next few years.

Analysis

Dr. Garfield's reform of his district's curriculum selection process required two significant changes in his practice. The first was to invent a set of questions about student learning that could guide the discussions. The second was to shift from a meeting style in which he directed the turn-taking in the discussion to one in which any member could comment on an idea that had been put forward. Interestingly, both of these are closely related to what transpires in reformed mathematics classrooms and their enactment suggests that Dr. Garfield had come to value these aspects of the reform movement and was changing his administrative practice to bring it in line with those new values.

But just what was it that Dr. Garfield knew? What was his leadership content knowledge? And how might his knowledge have been similar or different from Mrs. West's?

Knowledge of mathematics (the inner-most oval)

Dr. Garfield knew that mathematics was about ideas as well as about facts and procedures, and that learning mathematics entailed thinking about these mathematical ideas. He wanted the students in his district to be "mathematical thinkers," not "arithmetic practitioners," and he organized the entire curriculum selection process around the

question, "What kind of mathematical thinkers would our students be if we used this curriculum?" We don't have specific data about what Dr. Garfield knew, mathematically. However, his set of guiding questions provides a sense of what he thought it would be important for the committee to consider when they thought of the district's students as "mathematical thinkers." His work sheet had major sections for assessing curricula on their treatment of number sense, patterns and relationships, geometry and measurement and statistics and probability. The open-ended questions in each of these sections included questions like: how does the program develop understanding of the numeration system (counting, grouping, regrouping, place value); how does the program model, explain and develop understanding of basic facts and algorithms; how does the program develop understanding of: fractions, mixed numbers, decimals, percents, integers, and rational numbers? That is, his questions not only constituted a list of mathematical topics that should be treated by the curriculum, but emphasized that it was understanding that was valued, and implied that there might be a number of ways for students to reach that understanding and that how that was done mattered.

We have the sense that Dr. Garfield's knowledge of mathematics was less-detailed than Mrs. West's. He had been a literature major in college and was not particularly comfortable with mathematics. When observing videotapes of mathematics classes (his job responsibilities no longer included observing actual mathematics classes) he was not as able as Mrs. West to think critically about how well mathematical ideas were being represented by the teacher, nor as able to analyze the validity of the children's mathematical thinking. Rather, his views of mathematics were more general—focusing on the nature of the mathematics enterprise as a whole.

Knowledge of how children learn mathematics and how teachers can assist their learning (the second oval)

It was clear at the outset that Dr. Garfield knew that the kind of mathematics education described by the NCTM Standards, the Massachusetts Mathematics Framework, and many of the newly available elementary curricula, instantiated a different view of the nature of learning and teaching itself–that children build their own mathematics knowledge by thinking about mathematical ideas and working mathematics problems, not only by absorbing facts and practicing procedures. This lay behind his insistence that the curriculum selection committee analyze the kind of "mathematical thinkers," rather than "arithmetic practitioners" that students would be if a particular curriculum were adopted. But, once again, Dr. Garfield's knowledge of how children construct their mathematics knowledge was not as specific or detailed as Mrs. West's.

Knowledge of how teachers learn to teach mathematics and how others can assist their learning (the third oval)

Ethnographic data from the course he took with us suggests that Dr. Garfield thought teachers' ability to change their instruction to focus more on students' mathematical thinking depended on their developing the belief that children build their own knowledge, and that teachers would be motivated to change their instruction by seeing that their earlier teaching methods, no matter how well executed or well-motivated, were not sufficient to support students' understanding of mathematical ideas. And like Mrs. West, Dr. Garfield believed that teachers would need to experience mathematics learning as students, if they were to develop a deep understanding of mathematics instruction that supported students' mathematical thinking. As he put it,

> What [this] does is to replicate on an adult level what students are experiencing at their levels. . . . I think it's a good thing. I think this really is fresher, and more like what students' experience. And I think that's a very good thing. To be a true learner.

All of these ideas about teacher learning affected Dr. Garfield's sense of the nature of the professional development that would be required district-wide if the *Investigations* curriculum were to be well implemented—it would have to affect teachers' beliefs about the nature of learning as well as their teaching techniques and give them the opportunity to reconstruct their own mathematics knowledge. However, we do not see in Dr. Garfield the level of detail about the nature of teacher learning that we see in Mrs. West.

Knowledge of how to guide the learning of other adult professionals (the fourth oval)

In the case of Dr. Garfield we see an administrator looking *across* teachers and buildings as he led the task of selecting an elementary mathematics curriculum for an entire district. He also considered how he would interact with others in the system—the district math coordinator, elementary principals, and the School Committee—in getting the curriculum selection committee's decision implemented. Dr. Garfield was attending to a set of administrative processes with broader reach than was Mrs. West who was concerned with leading instructional improvement within one building. As such, he felt the need to establish an explicit process for curriculum selection in order to be able to present a credible and reasoned recommendation to the School Committee, and to deal with the budgetary implications of the curriculum selection. He designed the curriculum selection process so that he would be in the position to deal with all of these issues once the final decision had been made.

While Dr. Garfield's knowledge about the nature of mathematics learning and instruction gave him new goals for the curriculum selection process, he did not initially have techniques for achieving these goals. He was not clear initially about what he should do to transform the committee in the way that he wanted—what his new behavior should be—and he sought guidance from the EDC staff about the design of the initial session, about the general notion of open-ended questions (though he developed all of the actual questions used himself), and about his role in the committee. He was surprised at how lively the discussion process became, once he made space for it to happen in committee meetings, and how affirming the adults found it.

In this case, Dr. Garfield's content knowledge—his knowledge of mathematics, how children's mathematics knowledge develops, and how teachers learn—actually transformed his ideas about how to lead. His new ideas about the nature of mathematics instruction changed what he thought the curriculum selection committee should deliberate about, and his experience in a class that discussed ideas about mathematics gave him a model for how the committee could function. In essence, Dr. Garfield learned that leading school reform involves *organizing and leading the learning of others.* If the teachers and parents on his committee were to participate in the manner he desired, they would need to confront the discrepancy between their current beliefs and those instantiated in the standards documents. As he said, people have to "step into the Frameworks and . . . imagine what our instruction might be like and imagine what teaching might be like." He knew that members of the curriculum selection committee would vary in their understanding of and agreement with the new ideas about mathematics learning and teaching, and so there needed to be time for their ideas to emerge and be discussed.

So we see in the case of Dr. Garfield a dimension of leadership content knowledge that involves the facilitation of learning within an organization. This included knowing how to set a vision around the kind of mathematical thinkers their students should become, how to use external expertise (the video) to offset what he suspected would be a consistent within-group view of mathematics as the routine manipulation of symbols, and how to lead a group process that solicited, respected, *and* challenged individual points of view.

However, his new found insights about how leading and learning are intertwined reached its limits when he considered how to deal with the School Committee. In that context he was not thinking at all about organizing their learning, but rather how simply to shoot through the process, staying in "the chute," and emerge with the decision he wanted.

Case #3: Leading District-Wide Reform in Mathematics vs. Literacy: What Do District Leaders Need to Know?[11]

Our final case examines how leaders' work in one subject area is informed by their pre-existing knowledge and commitments in other subject areas. As such, it complicates the construct of leadership content knowledge by reminding us that leaders are responsible for multiple subject areas and that knowledge in one subject area may be more or less useful for leading reform in another content area. It complicates our story in a second way, as well. In this case we analyze the thoughts and actions of three leaders—an urban superintendent, his deputy, and the director of mathematics—and how they worked together to

lead a large-scale (25 elementary schools) instructional improvement effort. This case analyzes the knowledge that each leader brought to the table and how their distributed expertise influenced the design and enactment of systemic reform. As with the cases of Mrs. West and Dr. Garfield, we first tell the story and then analyze the kinds of knowledge that appeared to influence district leaders' decisions and actions.

Community School District #2 in New York City was one of the first districts to face the challenge of establishing capacity and leading reform in two content areas simultaneously. Having focused on systemic reform in literacy and raised student achievement scores during the initial eight years of his tenure, in 1995 Superintendent Alvarado and his staff[12] expanded their attention to include mathematics. At that time, the entire infrastructure of the K-8 system was designed to support ongoing improvements in literacy instruction. The Balanced Literacy Program guided all district-wide activities related to instructional improvement (Stein & D'Amico, 2002a). This included not only a common approach to literacy in all elementary classrooms but also an impressive array of aligned professional development experiences for both teachers and principals and a well-developed system of administrative support and evaluation of instruction. Moreover, individuals who had been selected because of their affinity toward literacy in general and their proficiency with the Balanced Literacy program in particular populated the principal and teaching ranks of District #2. Finally, both Superintendent Alvarado and his deputy were experts in the field of literacy and had relied on their content knowledge in literacy extensively in leading the literacy reforms (see Stein & D'Amico, 2002b).

Alvarado hired Carol Young as Director of Mathematics in 1995 and charged her with designing a plan for district-wide reform of mathematics. Young's knowledge of mathematics was grounded in her extensive training with national leaders in mathematics education and by the many roles that she had played in the New York City schools, including mathematics teacher, curriculum developer, assistant principal, and teacher supervisor.

Curriculum Selection

The first decision to be made was whether or not to adopt a curriculum to guide the reform effort in mathematics. Because District #2 educators had a long and proud tradition of developing their own instructional programs, this was not an easy decision. The Balanced Literacy program—although emanating from the Early Literacy Project at Ohio State University—was adapted and shaped by District #2 principals and teachers to suit their own ideas about best instructional practices. Moreover, it was not a curriculum in the traditional sense of the term, but rather a framework for how to organize instruction to assist children to learn to read increasingly challenging texts.

Despite the general unease surrounding the adoption of a curriculum, Young brought an important insight to bear on the decision—the understanding that mathematics was different from literacy in some very important ways—ways that made it more amenable to curricular guidance. First, Young argued that the content that students needed to learn was more definable and interrelated in mathematics than in literacy and hence (a) could be better captured in curricular materials; and (b) would demand more cross-grade articulation in order to serve students well. Second, Young argued that a curriculum was needed to scaffold *teachers'* learning of mathematics, as well as student learning. Unlike literacy, in which principals were able to provide the extra support teachers needed, the lack of expertise in mathematics among principals meant that such support would be less forthcoming, at least in the initial stages of the math initiative. The limited *human* infrastructure for supporting teacher learning, it was argued, needed to be augmented with a *material* infrastructure.

After careful review of a number of curricula by a group of teachers, as well as discussions with mathematics education experts, the district decided to adopt *Investigations in Number, Data and Space.* It is useful to note the many similarities between *Investigations* and the Balanced Literacy Program. Both feature cognitively rich tasks that require students to construct their own knowledge through high-level thinking and problem solving. Unlike more scripted programs, both depend upon teachers knowing their subject matter and their students in order to formulate and carry out moment-by-moment decisions in the classroom. Young, the superintendent, and the deputy all knew that they would need to plan carefully for the professional development of their teachers so that

they would be able to enact the *Investigations* curriculum.

Professional Development for Teachers

Unlike the decision regarding choice of curriculum where the field of literacy was clearly different from the field of mathematics, district leaders hoped to be able to directly transfer what had been learned about the organization and delivery of system-wide professional development in literacy to their design of professional development for mathematics. Not surprisingly, one year into the mathematics initiative, professional development in mathematics and literacy shared many features. Both aimed to reach all teachers (not a select group) and were focused on providing the support teachers would need to implement the initiatives well. Both were comprehensive and multi-faceted, meaning that teachers learned in a variety of venues, with a variety of individuals, and in a variety of ways. For example, professional development in each subject area occurred in well-coordinated, district- and school-based workshops; during carefully planned inter-visitations to other schools; during dedicated grade-level meetings within schools; and in individual classrooms through the assistance of school-based professional developers, sometimes referred to as coaches.

Unquestionably, the organizational blueprint for professional development in literacy served District #2 leaders well as they began their design of professional development for the mathematics initiative. However, the above similarities are at the level of forms, (i.e., program structures) not the content of what needed to be covered inside professional development. The fact that Young was designing professional development *in mathematics* created important differences between professional development in these two areas.

District-wide professional development in literacy was organized in terms of the components of the district's Balanced Literacy Program (e.g., Guided Reading, Shared Reading, etc.). In district leaders' experience, teachers tended to have different kinds of struggles with each component (Guided Reading being the most difficult) hence, it made sense to isolate each and focus on what is entailed in enacting it well. When teachers returned to their schools, they would receive assistance from their principal and more experienced teachers regarding how to integrate the new knowledge seamlessly into the overall program.

In mathematics, the organization of district-wide professional development around components was not a viable option. The mathematics initiative had no components that paralleled the components of Guiding Reading, Shared Reading and so forth. Rather the salient features of the initiative—in terms of what teachers needed to learn—were the mathematical ideas and concepts themselves along with knowledge regarding how these could best be taught and learned. Thus, by the second year, the *Investigations* curriculum itself served as the overarching framework for district-wide professional development. More specifically, professional development sessions were organized around the units of the *Investigations* curriculum. The goal of each session was to provide teachers with guidance regarding the mathematics in that unit, how to teach individual lessons within the unit, and the kind of student responses they might expect during particular lessons. These sessions were organized by grade level and timed to coincide with the month during which most teachers would be teaching that particular unit.[13]

Another important distinction concerned decisions regarding the stance toward teaching and learning that should be modeled. The mathematics professional development sessions that we observed often began with facilitators asking teachers to work on a mathematical task. Sometimes the task was the same one they would be asking their students to do; sometimes it was a "more adult" version of the student-level task. In either case, it was a complex, multifaceted task that demanded sustained reasoning and thinking. The reason for doing this was not only to assist teachers in building their substantive knowledge of mathematics, but also to give them the experience of actively making sense of mathematics (instead of passively receiving it) and of participating in a community of mathematical learners. By sharing their solution methods with the entire group and listening to others' methods, teachers learned not only the mathematics itself, but also the methods by which mathematical knowledge is developed, judged, and verified. Leaders would then ask teachers to reflect on that experience, especially with regard to the implications that it had for teachers as leaders of discourse in their own classrooms. In this way,

teachers could begin to better understand their role as facilitators of learning and socializers of student reasoning.

In contrast, in literacy workshops teachers seldom took the role of learner; rather, most of the time was spent observing models of good pedagogical practice. Teachers skipped directly to the role of the pedagogue—not pausing to consider how to learn the content at hand or how knowledge is constructed and verified in the domain. Given that most teachers were comfortable with their command of reading and writing, this would appear to make considerable sense. Nevertheless, by not experiencing learning in a particular community and reflecting on their methods for developing and verifying knowledge, teachers did not have the opportunity to encounter the underlying foundations of knowledge creation in the various domains that undergird literacy. For example, we never witnessed a discussion regarding how various schools of literature rest their interpretations of text in different forms of evidence (i.e., in the text itself, in knowledge about the author, in subjective responses of the reader).

Thus, although the structures of professional development remained unchanged, district leaders did not import their literacy professional development system wholesale into the design of support for teachers of mathematics. Young's knowledge of mathematics allowed them to realize early on that they would need a different organizing frame and that both the content and processes of professional development in mathematics would need to be different than it had been in literacy.

Professional Development for Principals

Given their role as both supporters and evaluators, District #2 principals constituted a critical leverage point in the district's theory of systemic instructional improvement. This approach worked well for the literacy initiative. Principals (many of whom already had literacy expertise based upon prior experiences as teachers or staff developers) received considerable amounts of professional development and support.[14] Indeed, district leaders believed that principals deserved as much professional support as did teachers. They argued that knowing how to teach oneself—or even knowing how to conduct good professional development sessions—was a necessary but not sufficient basis for instructional leadership. Missing was knowledge of how to *lead* reform, that is, how to identify and use the instructional and professional development expertise within one's building to develop capacity across the entire school faculty, how to effectively utilize coaches, how to partner more and less experienced teachers, and how to get the most mileage out of events that featured demonstrations of desired practice (e.g., how to free up teachers to observe demonstration lessons). This leadership knowledge was layered *on top of* a core of knowledge that principals presumably already had: knowledge of how children learn to read and what good literacy instruction looks like. As time went on, it was difficult to distinguish leadership knowledge from literacy knowledge; they were tightly bundled.

The opportunities for principals to learn how to lead in mathematics were different. Principals were urged to attend professional development sessions with their teachers so that they would learn some mathematics, but, more importantly, so that they would know what to look for in classrooms. A few principal conferences were devoted to mathematics, but began not with the basics of mathematical knowledge, how students learn mathematics, or how teachers learn to teach mathematics, but rather with the leadership layer (e.g., what to look for in classrooms; how to organize professional development.) Thus, principals had fewer and qualitatively different opportunities for learning how to lead school-wide instructional improvement efforts in mathematics. More specifically, the opportunities provided by the district skipped directly to the level of leadership knowledge without first laying down an intensive base of knowledge of teaching and learning in the domain of mathematics.

Analysis

Our analysis of the knowledge used by these district leaders makes use of similarities and differences between literacy and mathematics in order to surface the kinds of leadership content knowledge that were needed to lead reform in District #2.

Knowledge of subject matter (the inner-most oval)

One aspect of subject matter knowledge used in this case relates to the "disciplinary status" of literacy and mathematics (Stein & D'Amico, 2000). Compared to the kind of subject matter knowledge used by Mrs. West and Dr. Garfield, the understanding of subject matter used by the

District #2 team entails a broad, but also very deep, appreciation of the disciplinary roots of knowledge, of how knowledge is developed and verified, and of the role of "schools of thought" in defining what is worthwhile and acceptable.

School mathematics is comprised of a definable body of knowledge, a structure of interrelated concepts, a symbol system, and a vocabulary that—although not synonymous with—is derived from the discipline of mathematics. In recent years, school mathematics has expanded to include the experience of creating and using mathematics, not simply memorizing facts and repeating routine calculations. This aligns with current ways of viewing mathematics as an inherently social activity in which a community of trained practitioners uses the tools of abstraction, representation, and symbolic manipulation to engage in the study of patterns, to solve problems, and to create new understandings (Lakatos, 1976). Viewed in this way, mathematics—both disciplinary and school mathematics—goes well beyond knowledge of facts, concepts, algorithms, or definitions. What counts as knowing and doing mathematics also includes using tools in the service of creating, communicating, verifying and applying mathematical concepts and structure (Schoenfeld, 1992).

Compared to elementary school mathematics, elementary school literacy has a much less delineated knowledge base. Although the "content" of literacy has been variously defined as the grammatical and linguistic structure of written and spoken language, children's literature, phonics, and/or the writing process, the sum total of these does not represent "disciplinary knowledge" in the classic sense of the term. Rather the content of school literacy is dispersed among at least three academic disciplines (language, literature, and composition). These multiple and diverse perspectives on what should be taught under the banner of school literacy suggest the need to conceptualize its foundation differently from the singular disciplinary underpinning that can be identified for school mathematics.

The activities of learning to be literate and being literate also have different roots for school literacy. In mathematics, there are similarities between "doing mathematics" in school and the activity of practicing mathematicians. Lacking a single disciplinary home comparable to that noted for mathematics, school literacy has looked more broadly for models of literate practice. Ideas about what constitutes literate practice have been based upon models of knowing in literature, as well as methods of inquiry in a variety of other disciplines such as science and history. Even within literature, however, there is no one agreed-upon method for reading and interpreting text. Rather, the method one uses, depends on the academic community with which one identifies. These diverse underpinnings suggest that what "counts" as being literate and doing literacy-based practice is multidimensional, elusive, and not easily pinned down.

These understandings formed an important foundation for the curricular and professional development decisions that were made in District #2. Young's argument that mathematics was different from literacy and thus that the district's reform initiative in mathematics should be guided by a curriculum (despite the fact that the literacy initiative was not) rests upon many of the ideas outlined above. The content of the Balanced Literacy program was so large that it defied attempts to outline, structure, or place boundaries around it. Indeed, it often bled into other school subjects such as science, even in the primary grades. The *Investigations* curriculum, on the other hand, *does* specify the body of mathematical knowledge that elementary students should learn. Taking its cues from the national standards for school mathematics (NCTM, 1989) which, in turn, have been shaped by the discipline of mathematics, *Investigations* provides a set of topics to be covered, tasks for students to do when covering those topics, and a general sequence for those topics.

We can also see the influence of disciplinary ideas in the District #2 decisions that were made about teacher professional development. First, district-based mathematics professional development was to be organized around mathematical topics because the knowledge-to-be-learned is more delineated, organized, and sequenced. Given the large and diffuse knowledge base that undergirds literacy, it is more difficult to organize professional development around content topics. Second, the "insides" of mathematics professional development sessions were designed to be very different from the "insides" of literacy sessions. Following on the heels of contemporary ideas regarding what it means to know and do mathematics, mathematics professional development in District #2 stressed learning not only the mathematical concepts but also the methods of reasoning. We have noted that literacy professional de-

velopment did not include this aspect of "how one comes to know or justify something." Lacking strong univocal signals from a singular parent discipline, school literacy (for better or worse) is less easily defined and/or aligned with various "ways of knowing."

Knowledge of how children learn mathematics and how teachers can assist their learning (the second oval)

There were similarities in the knowledge about student learning in mathematics and literacy that appeared to underlie District #2 leaders' decisions. For example, reforms in both areas privileged the constructivist nature of student learning and viewed classroom discourse as an important vehicle for learning. District leaders' decisions reflected an understanding that students do not learn by receiving finished records of knowledge but rather must actively construct and interpret knowledge. These understandings about student learning were accompanied by a corresponding set of beliefs regarding pedagogy. Roughly stated, leaders believed that teachers should lecture less, ask fewer factual questions, and push student thinking through "higher order" questions—questions that require extended student reasoning and explanations. Rather than having all classroom talk filtered through and judged by the teacher, teachers should help students learn how to talk to and critique one another's responses. Superintendent Alvarado and his deputies clearly understood and were capable of building on the power of these similarities.

Less clear is the extent to which district leaders recognized strategic differences between teaching and learning in mathematics and literacy. For example, the role and nature of evidence clearly sets apart teaching and learning activities in these two domains. The justification of moves in a mathematics discussion must always rest upon mathematical evidence. Although evidence is called upon to support one's interpretations of literature, the nature of acceptable evidence and how it is integrated into one's arguments can be and is more variably defined. In some schools of literature, interpretation is rooted in the text itself. In others, consideration of the author and his/her background and intentions is necessary to unlock the true meaning of the text. In still other schools, interpretation rests on the subjective response of the reader to the text.

Knowledge of ways in which the nature of evidence varies in mathematics and literacy did not appear to be taken into account by district leaders as they unrolled the mathematics initiative on top of an existing literacy initiative. For example, despite teacher professional development in mathematics that emphasized methods of reasoning, we did not observe similar attention to the variety of possible "styles of reasoning" in literature discussions.[15] Lack of knowledge of this deep difference between mathematics and literacy showed up perhaps most clearly in the ways in which principals began to evaluate mathematics lessons; judging mathematics discussions solely by the linguistic *structure* of the discussion[16] or by rates and diversity of student participation with less attention to the mathematical ideas or reasoning strategies in play at the time.

Knowledge of how teachers learn to teach and how others can assist their learning (the third oval)

What was the nature of knowledge about teacher learning that under girded the district's responses to the challenges in this case? As with student learning, some of this knowledge was the same in both mathematics and literacy. For example, district leaders understood that teachers' opportunities to learn had to be directly related to the school subjects and curricular programs that comprised the improvement effort. In other words, if improvements in mathematics teaching and learning are needed, professional development on generic instructional strategies like cooperative learning will not help.

However, in other instances district leaders thought about professional development in literacy differently than in mathematics. For example, in mathematics, district leaders felt the need to place teachers in the positions of learners of mathematics, whereas they did not view this as an important aspect of professional development for teaching literacy, presumably because teachers were expected to already be competent readers and writers and may have been offended if asked to tackle a reading or writing task. More important, however, in mathematics, teachers were also seen to benefit from group discussions of mathematics. By discussing solution methods and their justifications, mathematics teachers were able to learn not only "how to do mathematics right" but also "how to think and reason in mathematically justifiable ways." Thus, the reasoning

went, they would be in a better position to understand their role as facilitators of such discourse in their own classrooms. In literacy, teachers did not participate in a community of learners that embodied particular norms of discourse. Therefore, they did not encounter the underlying foundations of knowledge creation in the various domains that under gird literacy. Nor were these foundations directly taught to them.

Knowledge of how principals learn to lead subject-matter reform and how to assist their learning (the fourth oval).[17]

What was the nature of knowledge about principal learning that under girded the district's reforms in mathematics and literacy? In literacy in District #2, it appears as though principals were expected to know everything that teachers and professional developers knew coupled with leadership knowledge that consists primarily of how to build the capacity of *groups* of teachers to improve. So what do district leaders need to know in order to assist principals to learn these things? The answer appears to be that the district leader needs to know everything the principal knows plus have an understanding of the challenges principals will face as they are learning these skills (most likely on the job), the developmental trajectories that principals go through, and how to scaffold principal learning at various stages of that developmental trajectory.

The question for mathematics, then, is, "Do district leaders who are responsible for the learning of principals have to travel back down into the depths of what teachers and staff developers and principals must know that is specific to mathematics and then layer on top of that knowledge regarding how principals learn to lead in mathematics?" Or is there some other way for them to configure their knowledge—a way that takes advantage of other resources in the environment and the sensibilities that they've developed from leading reform in one content area? We address these and other issues in the last section of this article.

Knowledge of how to guide the learning of teachers and principals within a community

District #2's leaders' knowledge of how to provide support to a community of literacy teachers was more robust and well-grounded than their knowledge of how to do so for mathematics teachers. For example, in the literacy reform, we witnessed leader knowledge that included not only how to help teachers to learn one-by-one, but also how to build the capacities of entire teaching staffs. This involved knowing how to arrange occasions in which one teacher could learn from another, to whom to assign coaches, and how to use both support and evaluation to move teachers forward. This knowledge was often very nuanced (Stein & D'Amico, 2002b). For example, when arranging for one teacher to visit and observe another, many dimensions of teacher learning were considered:

> You have to know where the teacher is on the continuum and what's going to help them move to the next step. It does sometimes help for teachers to see what the end goal is, so you may very well send them to a place like (the top school) where you have a really high level of teaching . . . but in the scaffolding of teacher learning you want to send the person to someone who is closer to where they're at and able to take them to the next level.

As indicated in this quotation, District #2 leaders were using an (implicit) developmental theory of how teachers learn to teach literacy along with a theory of how to provide scaffolded assistance based on where the teacher was in the developmental trajectory. Their knowledge of how to provide tailored assistance entailed being able to precisely identify a particular teacher's needs and then identify the most appropriate model for her to observe, a model that was selected from their knowledge base of all of the available learning resources (i.e., teachers in various stages of development) in the wider environment. Although the appropriate pairing of teachers may, at first glance, appear to be a generic skill of leadership, we did not see such pairings in mathematics, presumably because, other than Young, the top district administrators did not possess sufficient understanding of mathematics instructional practices and how teachers learn them to be able to identify such matches.

Leadership Content Knowledge

We started our exploration of leadership content knowledge by referring to Shulman's term pedagogical content knowledge—subject matter knowledge that becomes transformed for the purpose of teaching. In the final section of this article

we use the cases we have presented as context for discussing the characteristics of leadership content knowledge at different levels of the organization, how it relates to administrators' knowledge of leadership, and how leadership content knowledge can become available to leaders. We also identify a number of questions for further exploration.

Characteristics of Leadership Content Knowledge

In this section, we look across the three cases and attempt to characterize leadership content knowledge at each level of the organization at which it is called upon to do work. We begin by characterizing the kind of knowledge that the administrators in our cases had about the teaching and learning of subject matter in the classroom (the two inner-most ovals) and then move to their understandings of how to encourage teaching and learning at the school (third) and district (fourth oval) levels.

Knowledge of teaching and learning of subject matter in the classroom (the first two ovals)

All of the administrators in our cases used in their work some degree of subject matter knowledge (of either mathematics or literacy or both), knowledge of how children learn that subject, and knowledge of how to teach the subject. Mrs. West, whose responsibilities as principal of a school included observing in classrooms, supervising teachers, and making judgments about the quality of mathematics instruction in her school, was closest to the classroom, had the narrowest administrative function, and used the most detailed knowledge of mathematics and how children's mathematical thinking developed. She was able to follow the mathematical logic of the lesson, analyze the students' mathematical reasoning, and comment on the adequacy of the pedagogy of the lesson.

Dr. Garfield, an associate superintendent of a small district, was further removed from the classroom and the breadth of his administration function was wider, since he was responsible for an entire small district. The mathematics knowledge that Dr. Garfield used in chairing the curriculum selection committee seems to have been less detailed than Mrs. West's. In order to chair this committee he needed to know what the mathematics ideas and topics of the elementary curriculum were, and, in general, the kind of instruction that would enable students to become "mathematical thinkers" with respect to those ideas, and not simply memorizers of the facts and procedures connected to those ideas. He did not need to be able to make fine-grain judgments in classes, as Mrs. West did, nor to intervene with individual teachers, as she did.

In the case of District #2, which was also engaged in a district-wide process, we examined the relationship for district leaders of knowledge of two different subjects–literacy and mathematics. Our case suggests that they needed to know fundamental things about the way the fields of mathematics and literacy worked, what the nature of argument and evidence was in each field, and what the implications of this were for what should happen in classrooms and what teachers needed to know and know how to do. (Note that Mrs. West and Dr. Garfield may have needed knowledge about both literacy and mathematics in their work as well, but the comparison between disciplines was not salient for the administrative tasks we examined here.)

Notice that as we move away from the classroom, knowledge about subject matter does not disappear, and what administrators need to know does not become more generic. The needed knowledge remains anchored in knowledge of the subject and how students learn it. Indeed, in our judgment, the kind of knowledge exhibited by the leaders in District #2 is becoming increasingly important in the current climate in which classrooms are challenged to become communities of practice governed roughly by the same norms of argument and evidence as govern discourse in the disciplines. Like never before, teachers are charged with socializing students into particular ways of thinking, into specific methods of interacting with others about ideas, and into modes of reasoning that allow them to interpret, judge, critique, and even create new knowledge that will be recognized and accepted by their peers and the discipline. These are the kinds of understandings typically developed in courses on epistemology or the philosophy of knowledge. We argue, however, that these ideas have relevance for decisions made in guiding district-wide reforms that are deeply entwined with the content areas.

These reflections on administrator knowledge of subject matter and how it is learned suggest that characterizations of content knowledge for leadership may differ by function. We observed

Mrs. West as she was supervising and evaluating teachers, Dr. Garfield as he was leading a curriculum selection committee, and the District #2 leaders as they were planning a mathematics reform on the heels of a literacy reform. Each of these functions appeared to require different grain sizes of knowledge and different kinds of knowledge. Given that any one administrator may be called upon to perform any of these functions during his or her career, we are forced to consider how administrators can gain access to the knowledge they will need—how much administrators (at every level) need to know about *all* of the subjects taught in school. Is it reasonable to expect that elementary principals will have knowledge of every subject taught in their schools—mathematics, language and literature, science, social studies, and the arts—at the level of grain that Mrs. West exhibited in her knowledge of mathematics? And would this be possible for high school principals where subject matter knowledge is much more differentiated (several foreign languages, many sciences, etc.) and more advanced? And would it be reasonable to expect that associate superintendents would be equally conversant about curriculum, instruction, and professional development in all subjects, at all grades, K-12? This does not seem reasonable, on the face of it. But, as we have seen in our cases, depth of subject matter knowledge and knowledge of how students learn those subjects does seem to give administrators a significant advantage as effective instructional leaders.

We believe that there are two kinds of response to this dilemma, which are not mutually exclusive. One focuses on the education of administrators and the conditions under which they might continue acquiring subject matter knowledge throughout the course of their careers. The other focuses on the distributed nature of leadership and the opportunities that provides for administrators to build working groups that *collectively* have the needed knowledge. We discuss each of these briefly below.

With respect to what individual administrators should know, we suggest that, at a minimum, school and district administrators should have real depth of knowledge and expertise in one school subject. This may be the subject they studied most thoroughly in college, or loved teaching the most. We would expect that, as graduate students in administration, administrators would take additional courses in this subject and how it is learned and taught. In this "major" subject we would expect administrators to have both depth and breadth of subject matter knowledge and to know in considerable detail how children's knowledge of the subject develops—what ideas are typically difficult and why, what good instruction in this subject looks like, the characteristics of curricula that support student thinking well, the characteristics of professional development programs that support teacher learning well, and so on. That is, we would like to see administrators at all levels–principals, central office staff, associate superintendents, and superintendents—be quite thoroughly grounded in one subject, the way it is learned, the way it is taught, and ways to best support it from a leadership perspective. This will ensure that they truly understand what it means to have depth of understanding in a subject, what it means to learn and teach for deep subject-matter understanding, and what it means to provide effective organizational conditions that will allow adult professionals and students to learn.

However, we do not suggest that administrators' knowledge of other subjects is superficial or that they reason by analogy from the subject they do know to others. The District #2 case shows that it is not adequate for administrators to generalize from what they know about learning and teaching in one subject to another. The nature of the subject, itself, matters, and has implications for teaching and learning in that subject. Rather, our experience in teaching the ideas of elementary mathematics to practicing administrators suggests that administrators can develop their knowledge in a second, third, and perhaps even fourth subject by "postholing," that is by digging down deeply enough in a small but representative slice of knowledge in the second and third subjects to understand the nature of knowledge, learning, and teaching in that subject. We suggest that administrators need substantial experiences of some depth in every subject, in which they experience what it is like to be a learner of that subject, in which they study what is known about how children learn that subject and become familiar with the best instructional methods for that particular subject. From knowing a single subject well, administrators will bring to their exploration of the second and third subjects the recognition that every subject has its own domain of exploration, its own criteria for inquiry, its own rules of evidence and

argument. They will bring their knowledge that the primary learning task is for children to be building knowledge of the central knowledge structures and modes of inquiry of each subject and that it can be predicted that some ideas will be more difficult than others for many students. That is, from their knowledge of their first subject, administrators will have a general orientation toward knowledge, learning, and instruction and, in fairly focused explorations, will be able to see how such ideas are worked out specifically in other subjects. We are not arguing that administrators need equally broad and deep knowledge of every subject, but that such knowledge in one subject would prepare them to conduct highly focused explorations of other subjects in very productive ways.

However, there is another solution. Administrators do not work alone, but within complex networks of colleagues that form and re-form around specific tasks or issues (Elmore, 2000; Spillane, Diamond, Sherer, & Coldren, in press). Leadership can be viewed as distributed, or "stretched over" the practice of multiple people—principals and teachers in a school; principals and other principals in a district; teachers, principals and district subject-matter coordinators—as well as enabled by material artifacts such as observation protocols, curricular frameworks and so on (Rogoff, 1990; Spillane, Diamond, & Jita, 2003; Halverson, 2003). This distributed nature of leadership leads to another resolution of the dilemma about how much administrators need to know about every subject. Where individual administrators do not have the requisite knowledge for the task at hand they can count on the knowledge of others, if teams or task groups are composed with the recognition that such knowledge will be requisite and that *someone,* or some combination of people and supportive materials, will need to have it. Fore more information on the nature of distributed leadership, we refer readers to the works cited above.

Knowledge of teaching and learning at the school level (third oval)

To go back to our figure, as we move away from the classroom and toward the school level, not only do we see increasing breadth of function, but we also add additional levels of learners. That is, at every organizational level administrators also need to know about how the other adults in their purview learn. Teachers are concerned about subject knowledge and how students learn it. In order to provide instructional leadership for their faculty principals must add to their fine-grain knowledge of one or more subjects and how they are learned, knowledge of how *teachers* learn each subject and its pedagogy. Principals need to know the history of pedagogy in the subject (that is, how teachers might have been trained a number of years ago), the nature of teachers' subject matter knowledge, teacher misconceptions about subject matter and the learning of it, and how teachers work between developing new ideas (about the subject and its pedagogy) and developing new instructional practices. As suggested in the District #2 case, they also need to know how best to assist teachers in their learning, which includes being familiar with typical development trajectories of teacher learning and what kind of support is best for each level of learning.

Our cases also suggest that administrators have to know more than how teachers learn one-by-one, but also how to arrange environments that will continuously spur the learning of teachers-as-a-group, teachers who work in the same building or participate in some otherwise defined learning community. Knowing how to pair teachers together for peer observations, how to encourage a common vision and set of beliefs regarding student learning, how to arrange for competent substitutes on a regular basis, and how to schedule classes in order to allow for common planning times are only some of the forms of knowledge (knowledge that intersects organizations and learning) that competent administrators bring to their work.

Knowledge of teaching and learning at the district level (fourth oval)

Further out on the figure, central administrators need to develop knowledge about principals and other adult professionals as learners, as was true in the case of Dr. Garfield, but most obvious in the case of District #2, which struggled with how to help principals build on their knowledge of literacy to be ready for the challenges of a comparable reform in mathematics. Central office administrators need to know (a) what effective leaders of curriculum-based reforms need to learn; and (b) how they can best learn it. At minimum, then, the knowledge needed by central office administrators would include what it means to lead an organization and move whole groups of people to-

ward more sophisticated forms of teaching and learning.

The formation of learning environments for principals can be especially tricky because, unlike teachers, principals tend to work in separate buildings and to rarely talk to other principals. In large districts, a sense of learning community can be built by having monthly principals' conferences, by assigning principal mentors, and by offering principals study groups. In smaller districts, district leaders may need to seek out such communities in cross-district consortiums.

The Transformation of Subject Matter Knowledge for Leadership

In speaking of pedagogical content knowledge, Shulman argued that teachers transformed subject-matter knowledge into a form of knowledge that took into account its instructional intent. He had in mind the processes in which teachers who know their subject well use to develop versions of their content knowledge (problems to be solved, representations, metaphors, etc.) that are accessible to students. If we think of leadership content knowledge as a direct analogue of pedagogical content knowledge, we would look for the ways in which leaders transform their content knowledge for the purposes of leading. Do administrators transform their content knowledge into a form that makes it possible to lead? What would such transformations look like? What do administrators have to know about leadership in order to know how to transform content knowledge?

However, as we analyze even the few cases presented here, we see that in the case of leadership the issue of transformation may not be so straightforward. In some cases our administrators transformed their content knowledge for the purposes of leadership, as, for example, Dr. Garfield did when he transformed his mathematics content knowledge into a set of questions that the curriculum selection committee would use to evaluate candidate curricula. However, in other cases our administrators appeared to transform their sense of leadership on the basis of their content knowledge. In the same episode, Dr. Garfield had developed a new image of an intellectual community discussing mathematics, teaching, and learning, which generated a new view of how the curriculum selection committee could function, for which he needed to develop new skills. And in District #2, initially administrators' literacy content knowledge was intertwined with their leadership knowledge, so that the functions of teacher supervision and professional development were based on what was appropriate in the field of literacy. When District #2 began to consider reform in the field of mathematics, they had to un-bundle their leadership knowledge from its literacy-embeddedness and re-think it for the field of mathematics. As we saw, it was not appropriate to adopt an existing curriculum in literacy but it was in mathematics; professional development arrangements developed for literacy needed to be rethought for the field of mathematics; principals needed a new sense of what to look for when doing "walkthroughs" if they were to attend to mathematics instruction as well as literacy. It seems that leadership, which draws its basic ideas from the fields of sociology and organizational management, may itself become transformed when content knowledge is brought into play.

We now return to our "postholing" metaphor. If individual administrators are deeply rooted in one subject (or districts engage in thoroughgoing reform in one subject) we suspect that their leadership knowledge and their content knowledge will become co-defined. That is, some leadership practices will become transformed so that they are no longer generic, but subject-specific. When the individual administrator, or the district, takes on the second subject, some of this subject-embedded leadership knowledge may need to be rethought in terms of the characteristics of the new subject. Other aspects of leadership may be able to simply be reattached to the new subject. Distinguishing leadership knowledge that must be subject specific, from leadership knowledge that can be generic is an empirical question for future research.

Conclusion

In this article we have proposed that leadership content knowledge is a *missing paradigm* in the analysis of school and district leadership. We have defined leadership content knowledge as that knowledge of subjects and how students learn them that is used by administrators when they function as instructional leaders. We traced leadership content knowledge through three cases situated at different school and district levels, proposing that as administrative levels increase and functions become broader, leadership

content knowledge becomes less fine-grained, though always anchored in knowledge of the subject, how it is learned, and how it is taught. We have suggested that all administrators have solid mastery of at least one subject (and the learning and teaching of it) and that they develop expertise in other subjects by "postholing," that is, conducting in-depth explorations of an important but bounded slice of the subject, how it is learned, and how it is taught. The purpose of postholing is to learn how knowledge is built in that subject, what learning tasks should look like, and what good instruction looks like. Such knowledge on the part of administrators would provide grounding for distributed leadership in schools and districts that is based on shared subject knowledge. But where administrators' knowledge is thin, the development of working groups, networks, or teams that are deliberately comprised in such way that the requisite knowledge is held by others in the group would be an alternate way to ensure that the necessary expertise was available for decision-making and the development of school-wide or district-wide policies and plans. We proposed that at every administrative level leadership content knowledge includes knowledge of how the other adults in its purview learn, and we began an exploration of how content knowledge and leadership knowledge might be intertwined.

The construct of leadership content knowledge opens entirely new realms of thought about leadership—connecting it directly to the core function of schooling, learning and teaching—and raising the question whether generic studies of leadership can really get at the heart of what it means to lead schools and school districts. Without knowledge that connects subject matter, learning, and teaching to acts of leadership, leadership floats disconnected from the very processes it is designed to govern. Just as the construct of *pedagogical* content knowledge has marked out new and very generative research questions and sites for research, so the construct of *leadership* content knowledge may open up new questions about what it means to provide instructional leadership in schools.

Notes

[1] Increasingly, large urban districts, in particular, are designating administrative positions as specifically instructional positions. For example, in San Diego nine "Instructional Leaders" report to a "Chancellor for Instruction;" in New York City, 10 regions are divided into networks, each of which is overseen by a "Local Instructional Superintendent."

[2] Except for just having taken the mathematics education courses, the principals in this study were quite typical. All had been elementary teachers for at least eight years and elementary school principals for at least 10 years. All reported that they had not liked mathematics in school and took the minimal amount through high school and college.

[3] Spillane, Halverson, & Diamond (2001) and others have called attention to the fact that leadership is exercised not only by those in formally identified administrative positions but also by teacher leaders, department heads, resource teachers, and others. Elmore (2000) has also written about the role of distributed leadership in large-scale systemic reform.

[4] With the passage of No Child Left Behind, accountability models have come to dominate discussions of how to improve schools, the underlying theory being that sanctions applied to publicly identified poor performing schools and/or rewards provided to publicly identified successfully performing schools will motivate improvements in instructional practice. These approaches have been criticized as primarily leading to "teaching to the test" (McNeil, 2002), leaving unchanged the capacity of teachers to deliver more high quality and rigorous instruction. Learning models, on the other hand, posit that in order to bring about more ambitious teaching and learning in the classroom, individuals at all levels of the system need to learn to do something new. Teachers need to learn to teach in more cognitively demanding ways; principals need to learn how to assist teachers to teach in more demanding ways; and district leaders must learn how to assist principals to encourage teacher learning (Tharp & Gallimore, 1988; Stein & D'Amico, 2002b).

[5] Adapted from Brown, A. L. & Greeno, J. G. (1999). *Recommendations regarding research priorities: An Advisory Report to the National Educational Research Policy and Priorities Board* (section on *Teachers' Professional Development* headed by M. Lampert). Washington, DC: National Academy of Education.

[6] The names of administrators, schools, and districts in this case are pseudonyms.

[7] During the year of this study, we observed Mrs. West doing observations of mathematics instruction in five different classrooms. We observed her pre-observation conferences with these teachers, the classes she observed, and her post-observation conference with each teacher. We interviewed her before this series of events, after the observation of each class, and at the end of the observation sequence with teach teacher.

[8] The children had been told that there were 10 people on a vehicle (bus, raft, spaceship). They were to choose a number less than 10 to represent how many got off at a certain point, and then to figure out how

many were left on the vehicle. Their worksheet had pictures of the vehicles and they were to make a horizontal number sentence of the subtraction problem they generated. There was no subsequent whole-group discussion of this work.

[9] The names of administrators, schools, and districts in this case are pseudonyms.

[10] This case draws on an earlier version by Driscoll, Nelson, Sassi, and Kennedy (2000). For this case we interviewed Dr. Garfield at the beginning and at the end of the curriculum selection process. We observed every meeting of the curriculum selection committee and interviewed Dr. Garfield after each meeting about the actions he took (or didn't take) at that meeting. We also interviewed several members of the curriculum selection committee to ascertain how typical this curriculum selection process was in Avon.

[11] This case draws upon a large five-year data set collected as part of the High Performance Learning Communities project. The data include periodic interviews with the superintendent, deputy superintendent, and the director of professional development, as well as interviews with the director of mathematics. In addition, we conducted intensive case studies of nine schools in the district, which included classroom observations, interviews with teachers and other staff (including coaches), and ongoing interactions with and interviews of principals. Finally, we observed professional development in both literacy and mathematics and several of the monthly principal meetings.

[12] Other than Alvarado, all District #2 personnel are referred to by pseudonyms.

[13] There was a suggested district-wide sequence for the order in which units should be taught within each grade level.

[14] Some principals received mentors, all principals belonged to a principal support group, and the monthly principal conferences were devoted to issues of leadership in literacy.

[15] We saw little evidence that classroom discussions of text in District #2 incorporated different rules of evidence depending on the teachers' goals for the discussion and the underlying orientation that would have been appropriate for those goals. Teachers did not appear to be familiar with the range of conventions for building knowledge in the various disciplines that underlay school literacy in order to be able to help literacy students learn to adjust their styles of discourse depending on the models of literary practice being enacted.

[16] Structures include stylistic conventions such as building on the previous speaker's statements, often beginning with "I agree (or disagree) with ___ because."

[17] Because of the nature of the task discussed in this third case—district-wide mathematics reform—and District #2's philosophy of using principals as a linchpin in such reforms, the learning of principals becomes salient in this case, whereas it was not in the case of James Garfield (or at least not in the part of his responsibilities that we observed).

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Authors

MARY KAY STEIN is Associate Professor, School of Education, Research Scientist, Learning Research and Development Center, 828 LRDC Building, 3939 O'Hara Street, University of Pittsburgh, PA 15260; MKStein@pitt.edu. Her areas of specialization are mathematics teaching and learning, teacher professional development, relationship between policy/leadership and teacher learning.

BARBARA S. NELSON is Project Director, Education Development Center, 55 Chapel Street, Newton, MA 02458; bnelson@edc.org. Her areas of specialization are teacher learning in mathematics, mathematics education, administrator learning, and leadership content knowledge.

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